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experience in tutorial work with young men, Thackeray came as a revelation: he saw with Thackeray's eyes what life had failed to shew him, and bitterly did he regret he had not been set years before to study *The Virginians*, *Pendennis*, and *The Newcomes*, by way of *pädagogic*. To defend our young folk in danger we need prayer—that first and foremost; we need study—that of course; we need sympathy with their pursuits—that comes easy to us. But we also need to be *men*, with a man's broad view of life married to the high ideal and sensitive conscience of a woman. And that is what God gives to guard His children in the normal home. Unfortunately, few homes are normal or anything like it! One has heard of London clergy, whose nearest parishioners are surely they of their own household, beginning after years of "family" life to make the acquaintance of their own children. Surely, home is the first charge upon a man's spiritual energies: this ought he to do, and not leave the other undone. Fathers in business, with long hours and distant offices, are so little in the home that bread-winning comes to be considered their proper work, and child-training left to the wife—this to the loss of all concerned. To her loss, for the fair sharing of home duties is among the precious fruits of wedded love; to their loss, for God gave them two parents, and that is not one too many for their need. Yes, and to the father's loss, for his own growth is stunted, his life's training left incomplete. "What the women leave unfinished in our moral education," wrote Goethe, "the children complete in us." They react upon our characters with a spell that is nothing less than divine—

> "O dearest, dearest boy! my heart
> For better lore would seldom yearn,
> Could I but teach the hundredth part
> Of what from thee I learn."

RECKONING.

By P. G. O'Connell.

Part I.

All writers on education are agreed as to the iniquity of attempting to teach necessary facts by rote, yet nine British schoolmasters out of ten know of no better way. If they do not teach the multiplication table by rote themselves they expect their pupils to have been so taught. To the question, "Seven times nine?" they exact an answer given with a celerity that can only spring from rote learning. The inaccuracy, which is a necessary result, pursues the boy to his dying day, and should he later become a Senior Wrangler, he will still make occasional numerical mistakes. He may invent marvels, discover wonders, but the occasional numerical inaccuracy will cling to him for life.

Gaze into a baby's eyes as he diligently counts his toes. Can you not see that he is already learning the art of reckoning? Long before he can speak he is an adept at addition, subtraction, multiplication and division. He has convinced himself by experiment of the truth of many such necessary facts as that two and three make five, that twice four are eight, and three times three nine. You may be sure he makes no mistakes. Watch and see how carefully he repeats every operation until he has thoroughly convinced himself of the truth of the particular fact he is learning. It may fairly be maintained that he knows something of the art of reckoning, and it is sad that this knowledge should be driven out of him by foolish teachers, as it almost invariably is. It may be objected that a child who has never been to school, when asked what four and five make, will perhaps answer eight. That only proves that he does not yet quite understand the words four, five and eight.

To realise his condition, imagine that you yourself, who are no doubt a correct reckoner, were cast on an island among savages whose language you did not understand. Imagine that for your sins they sent you to their school; that before you had thoroughly learnt their outlandish names for the numbers they asked you what bing and bang made; that, while you were puzzling your brains as to the meaning of bing and bang, they boxed your ears for refusing to answer; and that they made you write out two hundred times, "Bing and bang make smash." Suppose you were held up to ridicule as a dunce because you did not know that bing and bang made smash. Suppose that during the whole long summer afternoon, while others were bathing or playing at "lishtosh," you were kept in a stuffy room, trying to burden your memory with a hundred and forty-four such dreary statements as that bing bangs are bok-shaw. Suppose that next day you were asked, with a frown or a sneer, the value of bing bangs, and threatened with punishment if you replied wrongly. Suppose this process were repeated day after day. Would it not tend to take from you the power of reckoning you already possessed?

Yet this is the process to which poor children are subjected, children of the rich as well as children of the poor. I have no hesitation in saying that every sane child knows his multiplication table before he can speak, just as you knew it before you were cast on the island of Bing Bang. I will go further and assert that he knows every necessary fact, though he realises at present very few. I think all will admit that every sane child knows the necessary fact that two and two make four. It is folly to pretend to teach such facts, though you may help a child to realise them, by giving him tin soldiers, or marbles, to play with, or by allowing him to make mud pies.

Let us see how we can copy nature in the matter of toys. Nature endows nearly every child at birth with a perfect set of toys; and the set she supplies to the cottage is usually superior to the set with which the palace has to be content. No two of these toys are precisely alike, and yet they are almost innumerable. Try to count the joints, nails and lines on one hand alone.

Notice that the child can get no harm from sucking these toys and trying to swallow them. Notice also the importance which nature attaches to the number five.

Suppose you give the child twenty-five wooden cubes, about an inch and a half each way; and, after he is quite tired of playing with them, pretend to play with them

yourself, arranging them first in five rows with five in each row, and then thus:—

ooooo ooooo
ooooo ooooo
ooooo

Now take only six cubes and arrange them, first in three rows with two in each row, then in two rows with three in each row, and then in one row, with a space between the fifth and sixth, thus:—

ooooo o

Be particular about this space. It is important that a child should never cease to realise six as five and one, seven as five and two, eight as five and three, nine as five and four, and ten as five and five. By this time the child wants to imitate you. Give him eight cubes and encourage him to imitate what you do with another eight. Then leave him to himself again. After a few days, present him with another twenty-five cubes; and repeat the process until he has a hundred, which you will gently encourage him to arrange in blocks of twenty-five, thus:—

ooooo ooooo
ooooo ooooo
ooooo ooooo
ooooo ooooo
ooooo ooooo

ooooo ooooo
ooooo ooooo
ooooo ooooo
ooooo ooooo
ooooo ooooo

The educational value of these hundred articles will not be fully realised until the child begins to learn the words one, two, three, etc. It will then, I think, be clearly seen.

What conception do the words "sixty-three" call up in your mind? A conception that I often meet with in the minds of my pupils, perhaps within a year of their wearing Her Majesty's uniform, is that of sixty-three people, in such a confused group that it is impossible for the mental eye to count them at a glance. The conception of a child, untaught save by nature, would probably be that of six pairs of hands and three odd fingers. I do not think that the ordinary kindergarten methods give as clear an idea, and of course I do not claim that the methods I use give a clearer idea, but I think I imitate nature's methods more closely than the ordinary kindergarten.

In order to "teach" a child that six and seven make thirteen, some teachers give him first six articles, then seven articles, and then tell him to count how many articles he has altogether. This is not a close imitation of nature, and therefore not a scientific method. Look at this diagram:—

o o o o o   o
o o o o o   o o

—Does it not show at a glance that six and seven are the same as two fives and one and two; that is, as ten and three; that is, as thirteen?

Look at this diagram:—

o o o o o   o o
o o o o o   o o
o o o o o   o o
o o o o o   o o
o o o o o   o o

o o o o o   o o

—Besides showing that six sevens are the same as seven sixes, it shows that six sevens are the same as five fives (left hand top quarter), and two fives (right hand top quarter), and one five (left hand bottom quarter), and two; that is, the same as eight fives and two; that is, as four tens and two; that is, as forty-two.

It is easy to see, in one's mind's eye, a similar diagram showing that seven nines are the same as eleven fives and two fours; that is, as twelve fives and one three; that is, as six tens and one three; that is, as sixty-three. The same diagram would show that seven nines are equal to seven tens all but seven; that is, to sixty-three. It is always well to have two ways of reckoning, that one may check the other. I say that I use these methods myself, but I must confess that I use mental images of soldiers instead of actual cubes, my pupils being of the class in favour of which the Government has lately rescinded the too stringent regulation that every British officer must, at one time in his life, have been

able to get two hundred marks out of five hundred in an easy arithmetic paper.

I find that, with the aid of a few diagrams, the so-called dull boy easily learns to form mental images, and enjoys thus testing that multiplication table which he knows, somewhat imperfectly, by rote. Moreover, a very little practice in thus testing the multiplication table up to ten times ten, enables a boy to realise a table up to twenty times twenty; to see, for instance, that thirteen seventeens are equivalent to ten tens, seven tens, three tens, and three sevens; that is, to two hundred and twenty-one. Indeed there is no limit to the distance to which the multiplication table thus studied may be carried; but the point that I wish to insist on is that the table should be thoroughly realised up to ten times ten.

I have also discovered a fact which I had not before realised, though reason might have suggested it to me, namely, that a little practice in thus testing the multiplication table up to ten times ten, enables a boy to multiply together correctly in his head any two binomial expressions in algebra. I commend this fact to the notice of all teachers who find it hard to teach their pupils the difference between the square of the sum of two numbers and the sum of their squares.

Such teachers usually lay all the blame on their pupils. That the fault lies wholly with the teachers I hope to show later.

PART II.

As I was walking along a country road one bright and frosty morning, I was passed by a man and a boy on a pair of first-class hacks.

"What makes the frost, father?" asked the boy.

"The cold, my boy," replied the man. The boy pondered in silence over this answer until they were out of my hearing.

The brief conversation may be taken as typical of the mental attitude of the average child, not merely willing, but burning, to learn. It also illustrates the mental condition of the average father, willing, if not very competent, to teach.

When we find this father handing his son over to a schoolmaster, less competent, and far less willing, to teach, we can only admire his modesty and deplore his lack of common sense. But when we find that many, who undertake to mould the minds of children, are not ashamed to own themselves unable to understand such a relatively simple subject as the Calculus, the question becomes rather one of morality.

What chance has a child of learning to reckon, when his teacher is not ashamed to own that he "never *could* understand Euclid?" Such teachers are, perhaps, not as common as they were; but the fact that advertisements for mathematical teachers often mention the "ability to solve easy Euclid riders," as a desideratum, leads one to suppose that many still profess to teach mathematics without pretending to possess the power referred to.

This being so, I do not expect all teachers to agree with me as to the intellect-dwarfing nature of the methods which are still in general use. I am also prepared for the argument that many first-class mathematicians have been "turned out" by our public schools.

The truth is that all first-class mathematicians have practically taught themselves. If a boy's intellect be a little above the average, or if he have been well started by a clever mother, his mind easily assimilates every new necessary fact as soon as it is presented to him. He is almost uninfluenced by his teacher, who is mostly occupied in trying to teach his unfortunate school-fellows by rote. Yet not always quite uninfluenced, for I have known a boy severely punished for proving a proposition in Euclid without looking at the figure. The boy was too proud to explain that he could see the figure perfectly clearly in his head; perhaps he thought it useless to argue with a fool. A really clever boy, being almost uninfluenced by his mathematical teacher, is able at the age of eighteen to enjoy the Differential and Integral; while his less fortunate companions are plaintively saying to an army tutor—"I've forgotten the rule for dividing by a half," or—"Don't ask me to think. When it comes to thinking I'm done for."

The first of these remarks shows the effect of teaching Arithmetic by rule. The second shows the state to which rote learning reduces the brain. I have heard it over and over again.

But the brightest gem in my collection came from a pupil whom I had provided with mathematical instruments and told to draw a circle and cut off a quarter of it. After trying hard for ten minutes, he said—

"Please, sir, I can't. The circle isn't big enough."

"Draw a bigger circle," said I.

"Please sir, I can't. It goes off the paper."

This boy could rattle off any number of definitions, which he had learnt by rote; and he was very anxious to get on; but he honestly believed himself incapable of "learning" Euclid. His condition may be compared to that of a starving man, who has entered a baker's shop to buy bread, but has been kept waiting so long, listening to, and patiently learning by rote, long definitions of corn, mill, flour, bakery, etc., that, when the bread is at last given to him, he has lost the power to digest it. Such a man may be resuscitated by a diet of milk and water; and the boy eventually passed his examination; but it takes a long time to restore to such minds the powers they possessed in babyhood.

A man, reputed clever in his profession, once told me that he could not, for the life of him, see how to prove that the difference between a third and a quarter was a twelfth, though of course he knew that it was. I wondered *how* he knew, but, as I presumed that he was trying to assist in the education of his children, I said to him, as I would to a child:—

"Suppose you were to divide a cake into three equal parts, then each of these would be one-third of the cake. Suppose you now divide each third into four equal parts, then you will have twelve equal pieces of cake, each exactly one-twelfth of the cake. Thus one-third of the cake is equal to four twelfths of the cake. But if you divide the cake first into four equal parts and then each quarter into three equal parts, you will see that each quarter is only equal to three-twelfths."

"I see," he replied, "you *must* bring them to a common denominator."

Thus the dry husk of the rule had lingered in his memory, while the solid knowledge it was supposed to contain had passed away as waste.

To a mind capable of forming clear mental images the above illustration gives the power of finding the product, sum, or difference, of any two fractions; but a still clearer illustration may be given by the aid of the toys mentioned in the first part of this paper. If a rectangle be formed, of three rows, with four articles in each row, it is easy to see that each row is one-third of the whole, each column a quarter, and each article one-twelfth.

The words "divided by two-thirds" are not easily understood by a child. If he be told that they mean "divided by two and multiplied by three," he wonders why, and sometimes his teacher cannot tell him; but if he be encouraged to draw lines six inches long, and divide one into portions two-thirds of an inch long, another into portions three-quarters of an inch long, and another into portions four-tenths of an inch long, he soon realises the meaning of the words "divided by two-thirds," and before long he notices that they mean the same as "divided by two and multiplied by three." Knowledge thus gained is assimilated, and becomes a part of the mental system; whereas that which has been learnt by rote is to the mental system what foreign matter is to the physical system, the origin of disease.

Accurate instruments for measuring are the most potent aids to education, but much may be done with a postcard and a pencil. A child cannot too soon begin making measurements himself. When he has made and used a scale of inches, divided to tenths of an inch, he practically understands the decimal notation without having learnt it. Decimals may also be introduced as follows. Since twenty-five is a quarter of a hundred, therefore twenty-five times any number is a quarter of that number of hundreds; similarly one twenty-fifth of any number is one hundredth of four times that number. Now one hundredth of such a number as three hundred and twenty-four is easily seen to be three, and twenty-four hundredths. That this may be written 3·24 is not hard to remember; and a child appreciates the advantage of making a dot do the work of a line and three figures.

The most interesting examples may be found in dynamics. Every boy takes an interest in the velocity of a falling stone and the path of a cricket ball; and, if long words and definitions be discarded, dynamics is as easy as it is interesting. Yet I have seen a boy multiply thirty-two by twenty-five on paper, and get the answer wrong from force of habit.

The idea of teaching reckoning by the aid of dynamics may seem strange to some, but it is not a new idea; it has received the approbation of the wisest men of all ages. The most highly trained mind can only realise the abstract through the concrete; for instance, the conception of an nth differential coefficient is only possible to those who instinctively, though perhaps unconsciously, give it a concrete form; and the folly of commencing education with rules for the handling of abstract ideas has often been demonstrated; yet, incredible as it seems, this is still the almost universal practice. Perhaps the secret lies in a remark once made to me by a wrangler: "I do not claim to be an educationalist, I only profess to be a teacher of young men."

Such teachers naturally consider that their duty is to impart knowledge. They are like a little girl I once knew, who made a dying rose tree look very pretty and bright by tying cut roses to its branches. An expert gardener would have merely watered the roots of the rose tree; an expert educator will often merely water the roots of intellect, leaving knowledge to come of its own accord. It seems as if the teachers of to-day were determined not to learn the science of education.

Yet, if it were not a cheat,
If science were all that it seemed,
Education all that I dreamed,
Then learning were not so bitter
But a smile could make it sweet!